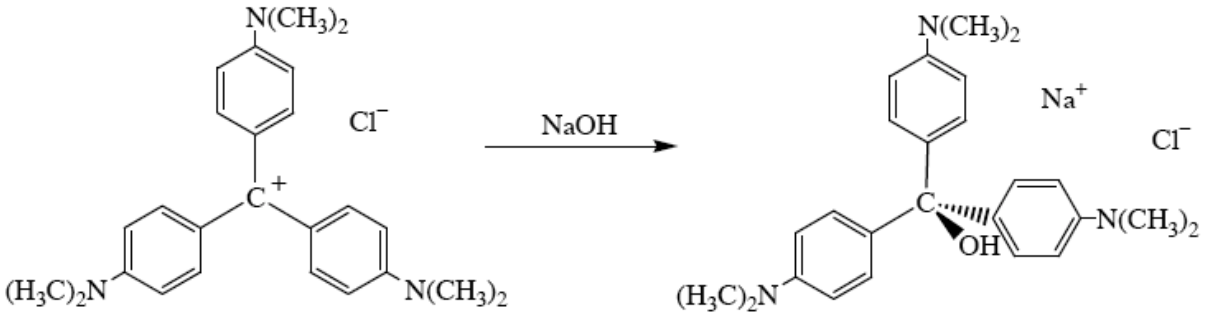
Rate Law Determination of the Crystal Violet Reaction

In this experiment, you will observe the reaction between crystal violet and sodium hydroxide. Crystal violet is a biological stain commonly used in used in Gram staining. One objective is to study the relationship between the concentration of crystal violet and the time elapsed during the reaction. The equation for the reaction is shown below:



A simplified version of the reaction is:

$$\underset{\text{crystal violet}}{CV^+} + \underset{\text{hydroxide}}{OH^-} \rightarrow CVOH$$

The rate law for this reaction is in the form:

$$\text{Rate} = k[CV^+]^m[OH^-]^n$$

Where *k* is the rate constant fro the reaction, *m* is the order with respect to crystal violet (CV^+), and *n* is the order with respect to the hydroxide ion. Since the hydroxide ion concentration will be more than 5000 times larger than the concentration of crystal violet, [OH^-] will not change appreciably during the experiment. Thus you will find the order with respect to crystal violet (*m)*, but not the order with respect to hydroxide (*n*).

As the reaction proceeds, a violet-colored reactant will be slowly changing to a colorless product. Using the green (565 nm) light source of a colorimeter, you will monitor the absorbance of the crystal violet with time. You will collect the absorbance data as a function using the CBL and then analyze the data using Excel. We will assume that Beer's law is true and the absorbance of light is proportional to the concentration of crystal violet. (Note: you will actually perform calculations with Beer's Law in future labs.) Absorbance will be used in place of concentration plotting the following three graphs:

- Absorbance vs.time: A linear plot indicates a *zero order* reaction (*k* = -slope)
- lnAbsorbance vs. time: A linear plot indicates a *first order* reaction (*k* = -slope)
- 1/Absorbance vs. time: A linear plot indicates a *second order* reaction (*k* = slope)

Once the order with respect to crystal violet has been determined you will also be finding the rate constant, *k*, and the half-life for this reaction.

Materials

Logger Pro	0.1 *M* NaOH (you have already prepared this)
Netbook	2.0×10^{-5} *M* crystal violet
Vernier Colorimeter	distilled water
one plastic cuvette	stirring rod
100 mL Beaker	two 10 mL graduated cylinders

Procedure

1. Obtain and wear goggles.
2. Obtain 5 mL each of 0.10 *M* NaOH and 2.0×10^{-5} *M* crystal violet.
3. Set up Netbook and plug the colorimeter into the computer via the Go!Link cable.
4. Set up LoggerPro to recognize the Colorimeter (in the list of probes, it is on the 2nd page).
5. Calibrate the colorimeter. First, prepare a blank by filling a cuvette ¾ full with distilled water. Place the cuvette in the colorimeter and then close the lid. Turn the wavelength knob to read 0% T position. Then select "CALIBRATE" from the EXPERIMENT menu. When the voltage reading stabilizes, input "0" and press "ENTER" in the Reading 1 window. Now turn the wavelength knob of the colorimeter to the Green position. Again when the voltage stabilizes, press input "100" and press the "ENTER" button in the reading 2 window. Press "OK" to return to data collection screen.
6. Set up the computer for data collection. In the data collection menu, enter 180 seconds as the experiment length and 4 as the **seconds/sample.** If this done right you should have 0.25 as your samples/second and you should collect 46 samples.
7. Now start the reaction. (NOTE: Move quickly, as crystal violet is light sensitive.) Pour 5 mL of crystal violet and 5 mL of NaOH into a 100 mL beaker and stir. Rinse the cuvette with 1 mL of reaction mixture and then fill the cuvette ¾ full. Place the cuvette in colorimeter and close the lid. Monitor the absorbance reading on the computer for 10 seconds. The absorbance should be gradually decreasing. Press the collect data button to begin collecting data. Observe the solution in the beaker throughout the lab.
8. All waste may be discarded in the sink. Any glass stained with crystal violet may be rinsed with hydrochloric acid.

MAKE SURE THERE IS NOT CUVETTE IN THE COLORIMETER WHEN YOU GO TO PUT IT AWAY!

9. Transfer data from LoggerPro into Excel. Analyze the data graphically to determine if the reaction is zero, first, or second order with respect to crystal violet. Make sure to print and secure the data table and graphs in your lab notebook.

Questions

1. Was the reaction zero, first, or second order with respect to the concentration of crystal violet?
2. Calculate the rate constant, *k.*
3. Write the correct Rate Law Expression for the reaction, in terms of crystal violet.
4. Using the printed data table, estimate the half-life of the reaction.
5. What is the concentration of crystal violet in solution at time = 0?
6. Define the term *pseudo-order.*
7. Write the integrated rate laws for zero, first, and second order reactions and sketch graphs of each vs. time.